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# Migration, Savings and Uncertainty

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# Migration, Savings and Uncertainty*

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**Abstract**

This paper analyzes savings behavior and migration decisions of temporary migrants. Special attention is given to the impact of a stochastic environment on the migrant's choice. The paper emphasizes two aspects which are likely to explain to some extend the relatively high savings of migrant workers: savings due to life cycle motives, and savings due to precautionary motives. Furthermore, the impact of uncertainty about future income on the migration decision as such and on the time the migrant wishes to stay in the host country is analyzed. The results show that the effect of uncertainty on the time the migrant intends to stay abroad is ambiguous. It depends not only in sign, but also in size on the utility structure of the migrant worker as well as on characteristics of the economies of host- and home country.

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# 1 Introduction

A major form of intra-European migration and migration into Europe, but also of intra-Asian migration and migration between Asia and countries of the Middle East, is "guest worker", or, more generally, return migration. The impact of this form of migration on the economies of both the labor-exporting country and the labor-importing country differs in many aspects from that of permanent migration. In contrast to permanent migrants, temporary migrants invest a large proportion of their earnings either into savings in the host country, or they transfer it to their home country, where it is then saved or used to support family members. Both the amounts of money that are transferred back home and that are saved in the host country have important implications for the economies considered. For the emigration country, transferred money is a major balance of payment support.[1] For the immigration country, transfers contribute largely to the balance of payments deficit.[2] On the other side, savings of migrants in the host country provide a substantial part of the domestic savings of immigration countries and contribute to their capital formation (Macmillan, 1982, p.251)[3].

Despite the importance of migrant's consumption- and savings behavior, there has been surprisingly little theoretical research on this topic. One difficulty when dealing with this subject is that earnings not used for consumption in the host country are not necessarily saved; they are partly used to support family members in the home countries. On the other side, earnings that are transferred to the home countries are

[1]In 1973, transfers from Turkish and Yugoslav workers in Germany amounted to over twice the total exchange obtained through exports of goods from these countries to Germany (Hiemenz and Schatz, 1979, p.1). Over the period from 1960 to 1984, transfers of Greek workers from Germany to Greece amounted to 16% of Greece's capital goods exports over that period (Glytsos, 1988, p.525). Transfers from Thai workers in the Middle East in 1981 were equivalent to about 6% of the total value of exports from Thailand in that year (Pitayanon, 1986, p.273). Remittances of Pakistanis from the Middle East finance some 86% of Pakistan's trade deficit (Robinson (1986)).

[2]For instance, transfers of migrant workers from Germany to their home countries amounted to 40% of the total deficit of the German account of services and transfers with foreign countries (Monatsberichte der deutschen Bundesbank, 1974, p.22).

[3]Jones and Smith (1970) report that the local savings rate (earnings that are invested into savings in the host country) of migrant workers in Great Britain in 1965 was about 2% above UK average. For France, the average local savings of foreign workers in 1970 was 50% higher than those of a French person with the same income (Granier and Marciano, 1975).

not entirely consumed, but to a large part invested into savings. There is a confusing use of concepts in the literature: While official data usually refer to all foreign exchange of migrants to the home countries as *remittances*, it would be wrong to conclude that all such transfers are completely consumed by family members. A large part of these transfers are saved in the home countries.[4] On the other side, it would be similarly wrong to interpret all earnings that are not consumed as savings, since a part of it is used for the support of family members. Following Paine (1974), *remittances* will here be used in the more narrow sense of earnings that are used to support family members. Savings are then all earnings that are saved at home and abroad[5]. The strict differentiation of income that is not consumed in the host country into savings and remittances is important for analytical purposes. While remittances are best analyzed in a family context (see, e.g., Lucas and Stark (1985)), for the analysis of savings behavior an individual approach seems more appropriate.[6]

One aim of this study is to explain why migrant workers have a different savings behavior than native workers. The analysis isolates two motives which are likely to explain to some degree differences in the savings rates of migrants and natives: life cycle motives and precautionary motives. The extent to which life cycle motives account for the excess savings of migrants, relative to comparable native workers, is shown to depend on the wage differential and the relative price level between host- and home country, the migrant's preference for consumption at home, and the desired length of migration. The analysis further reveals that the extent to which precautionary savings of migrants are higher than those of comparable natives depends on the migrant's utility structure, the perceived degree of risk of the labor markets of host- and home country and the correlation between the effects of some events on the economies considered.

A further focus of the analysis is the impact of uncertainty about future income streams in both, host- and home country, on the desired length of migration and, in the limit, on the migration decision itself. The results show that no general conclusions are possible. Contrasted with a certain environment, uncertainty influences the migrant's

[4]Monatsberichte der deutschen Bundesbank, 1974, p. 275

[5]According to Paine (1974, p. 103), only survey data allow for such a differentiation. For Turkish workers abroad, Paine calculates for 1971 an average saving rate of 36% of total income. A further 11% was used to support family members. These numbers indicate that savings net of remittances are still surprisingly high.

[6]For an empirical analysis of both savings and remittances of migrant workers, see Merkle and Zimmermann (1992).

choice. However, it's effect depends not only in size, but also in sign on the migrant's utility structure, on the riskiness of the host country labor market, relative to that of the home country, and on interdependencies between the effects of external shocks on both economies.

The next section will first introduce the theoretical framework. It will then be shown how the wage differences in home- and host country, preferences for consumption at home as well as uncertainty with respect to future earnings may influence the migrant's savings behavior. As a point of reference, migrant's savings behavior will be compared with that of native workers. The second part of the analysis concerns the impact of uncertainty on the migrant's decision to migrate and on the length of his stay abroad. Results are then illustrated with a numerical example.

## 2 Saving and Migration Decisions

Let the migrant worker be confronted with the following decision problem: At some point in time, he has to decide whether he wants to migrate to a potential host country and for how long. He further has to decide about his future path of consumption. An important motive for migration would be a higher rental rate on a unit of human capital stock in the potential immigration country. The worker would then migrate when the economic advantages of doing so outweigh the cost of migration, or, following Sjaastad (1962), when the present value of the migration decision is positive. This is also the classical explanation for labor mobility: As Hicks (1932, p.76) pointed out, "...differences in economic advantages, chiefly differences in wages, are the main causes of migration." However, it implies that the worker's objective is only to maximize lifetime income: his decision would solely be influenced by monetary aspects. Should this be the case, and once having decided to migrate, is there any reason for the worker to return to his home country? In other words, is such a simple model capable to explain temporary migration? Obviously not, or only under certain assumptions on the process of human capital accumulation, and the evaluation of human capital, in both countries.[7]

A simple extension of the model would be to let the potential migrant maximize lifetime utility from consumption, given a lifetime budget constraint that depends on

[7]This is outlined in Appendix 2.

the migration decision. When the migrant prefers to consume at home than abroad (because of other arguments that are complementary to consumption, like being together with his family and friends, living in a used environment, enjoying the climate etc.), his optimal decision may now be to migrate only *temporarily*, although the value of the stock of his human capital is higher abroad.[8] The reason for this is that, since his lifetime is finite, each unit of time spent abroad increases his lifetime utility by raising his total consumption possibilities, but it decreases lifetime utility by reducing the time available for consumption at home.

## 2.1 The Basic Model

Let the lifetime horizon of the migrant be equal to $T = 1$ and assume, for simplicity, that the worker is productive over his entire life cycle. The migrant will have to choose the time $t$ he wants to stay in the host country, thereby determining the time $(1 - t)$ he will afterwards stay in his home country. The migrant's objective is to maximize utility from consumption. Let his lifetime utility function be additively separable with respect to home- and host country consumption, with the subutility functions being increasing in consumption, strictly concave and continuously differentiable. Assume that the rate of time preference and the interest rate are both equal to zero. This does not change any qualitative results of the analysis that follows, but it implies that the flows of consumption in host- and home country are both constant. The migrant's lifetime utility may be expressed in the following simple form:

$$V(c^I, c^E) = t\, u^I(c^I) + (1 - t)u^E(c^E) \tag{1}$$

where $u^I$ and $u^E$ are the subutility functions in the immigration- and the emigration country[9], and $c^I$ and $c^E$ are the respective constant flows of consumption. A higher preference for consumption at home corresponds to a higher marginal utility from consuming an equal consumption flow $k$ in the home country: $u'^E(k) > u'^I(k)$.[10]

[8]The trade off between higher wages in the host country on the one side, and a higher preference for consumption at home on the other side was firstly formalized by Djajic and Milboune (1988).

[9]Immigration- and emigration country will be alternatively referred to as host- and home county.

[10]$u^I(c^I)$ and $u^E(c^E)$ could likewise be expressed as $u(c^I, G)$ and $u(c^E, F)$, where $G$ and $F$ are indices, representing environmental factors like family, friends etc. When $G$ and $F$ are complementary to $c^I$ and $c^E$, respectively, (in the sense of Pareto and Edgeworth, see Hicks (1979), p.44), and if additionally $F > G$, then $u'^E(k, G) > u'^I(k, F)$. For simplicity, the indices $G$ and $F$ are suppressed here.

Total future earnings in host- and home country are given by $y^I(t,x)$ and $y^E(t,z)$, where $x$ and $z$ are random variables with known joint density function $f(x,z)$. These random variables could be interpreted as indices which reflect the impact of uncertainty on future incomes in host- and home country.[11] The variances of $x$ and $z$ will be denoted by $\sigma_x^2$ and $\sigma_z^2$, respectively, and the covariance between both by $\sigma_{xz}$. The following assumptions seem to be natural:

$$y_t^I > 0; \quad y_t^E < 0; \quad y_x^I > 0; \quad y_z^E > 0 \tag{2}$$

This simply implies that total earnings accumulated in either country are the higher the longer the migrant will stay.[12] If interpreting $x$ and $y$ as indices of labor market conditions, the signs of the last two terms are self explaining: the more favorable the state of the world, the higher will be total earnings, keeping $t$ constant.

The migrant's budget constraint is then given by the following expression:

$$t\,p\,c^I + [1-t]\,c^E + \eta = y^I(t,x) + y^E(t,z) \tag{3}$$

where $p$ is the price level in the host country, relative to that in the home country, and $\eta$ are fixed costs of migration. Rewriting (3) yields:

$$c^E = \frac{1}{1-t}\,[y^I(t,x) + y^E(t,z) - \eta - t\,p\,c^I] \tag{4}$$

Inserting (4) into (1) and adopting the von Neumann - Morgenstern hypothesis of expected utility maximization, the individual will solve the following problem:

$$\phi(c^I,t) = \max_{t,c^I} E(V(c^I,c^E)) \tag{5}$$

Accordingly, the migrant will choose the level of consumption abroad, $c^I$, and the time $t$ to stay in the host country so as to maximize expected lifetime utility.

Since any uncertainty will not be resolved before $t$ and $c^I$ are chosen, the following restriction has to be imposed on the migrant's total consumption in the host country:

[11] For instance, when risk affects income in a multiplicative form, then $y^I = \bar{y}^I(t)\,x$ and $y^E = \bar{y^E}(t)\,z$, where $\bar{y}^I$ and $\bar{y^E}$ are total incomes in home- and host country as functions of $t$.

[12] Because lifetime is finite and $t$ signifies the time being in the host country, an increase in $t$ will increase $y^I(.)$, but it will decrease $y^E(.)$, since less time is available for the accumulation of earnings at home.

$$t\,p\,c^I \leq [y^I(t,\underline{x}) + y^E(t,\underline{z}) - \eta] \tag{6}$$

where $\underline{x}$ and $\underline{z}$ are the minimum levels of $x$ and $z$. Relation (6) simply states that total consumption in the host country has to be lower than total lifetime earnings when the most unfavorable states of the world should realize.

The first order conditions for an interior maximum are given by:

$$\phi_t = E[u^I(c^I) - u^E(c^E)] + E\left[u'^E(c^E)\,\frac{dc^E}{dt}\,[1-t]\right] = 0 \tag{7-a}$$

$$\phi_{c^I} = E[u'^I(c^I) - p\,u'^E(c^E)] = 0 \tag{7-b}$$

Relation (7-a) implicitly determines the optimal length of stay in the immigration country. The optimal $t$ will be chosen so as to equalize the expected marginal loss in overall utility of staying one unit of time longer in the host country with the expected marginal gain of staying one unit longer abroad, both measured in units of utility.

Expression (7-b) simply states that the expected marginal rate of substitution between consumption at home and abroad has to equal the relative price level.

### *Type 1* and *Type 2* Uncertainty

Income uncertainty that affects the migrant's decision problem may be due to unforeseeable future events that influence labor markets, and therefore earnings, of host- and source country. It may also be due to imperfect knowledge about the labor market conditions in the host country. Both types of uncertainty have different characteristics and may have different consequences for the migrant's decisions. The first kind of uncertainty will further be referred to as *type 1* uncertainty. The latter type is denoted as *type 2* uncertainty. The analysis below relates solely to *type 1* uncertainty. Implications of *type 2* uncertainty will be pointed out later.

Some examples for *type 1* uncertainty would be unforeseeable changes in raw material prices, like an oil crisis, wars, worldwide economic downturns, political unrest etc. For this type of uncertainty, it seems appropriate to assume that, the longer the migrant intends to stay in either country, the stronger will be the impact of some shock on his total income to be accumulated in that country. Formally, this can be expressed

by assuming that $y^I_{tx} > 0$ and $y^E_{tz} < 0$.[13] In other words, marginal total income at home and abroad, which are earnings per unit of time, increase in $x$ and $z$ respectively.[14] This is what Levhari and Weiss (1974) call *increasing risk* and implies that the variability of total income, accumulated in either country, increases with the time being in that country. Increasing risk would correspond to a multiplicative specification of the effect of uncertainty on earnings, as it is usually assumed in the literature on uncertainty and investment into human capital (see, for example, Eaton and Rosen (1980), Kodde (1986)).

**The Deterministic Case**

Reconsider the migrant's optimization problem in a deterministic world. Assume, therefore, that $x$ and $z$ are known to be equal to their expected values: $x = E(x) = \tilde{x}$ and $z = E(z) = \tilde{z}$. It then follows for (7-a) and (7-b):

$$[u^E(c^E) - u^I(c^I)] = \left[u'^E(c^E)\frac{dc^E}{dt}[1-t]\right] \tag{8-a}$$

$$u'^I(c^I) = p\,u'^E(c^E) \tag{8-b}$$

The system (8-a), (8-b) determines the optimal time to be spent abroad, $t^0$, and the optimal level of consumption in the host country, $c^{I0}$. For an equal price level in both countries ($p = 1$), and expressing a higher preference for consumption at home by a higher marginal utility of a constant flow of consumption $k$ in the home country, $u'^E(k) > u'^I(k)$, it follows from (8-b) that the optimal level of consumption at home is higher than the optimal level of consumption abroad: $c^{E0} > c^{I0}$. Throughout the analysis, it will be assumed that the migrant has a higher preference for consumption at home, which ensures an interior solution for the time spent abroad (corresponding to temporary migration). It follows then from (8-a) that he will decide to migrate when the increase in lifetime utility from staying one unit longer abroad is at least as high as the decrease in lifetime utility by being deprived of the possibility to consume during this unit of time at home.

For completeness, consider the case where the migrant is indifferent between consumption at home and abroad. This would correspond to $u'^I(k)$ being equal to

[13]Note again that an increase in $t$ decreases the time being in the home country, so that $y_t < 0$.

[14]This includes the possibility of unemployment. Marginal total income would then correspond to eventual unemployment benefits.

$u'^E(k)$, and, consequently, $c^{I0} = c^{E0}$ and $u^I(c^{I0}) = u^E(c^{E0})$. The migrant's decision will now depend solely on earnings prospects at home and abroad – the classical explanation for migration. For an equal price level in both countries ($p = 1$), and indifference between consumption at home and abroad, (8-a) reduces to

$$u'^E(c^E)\,[y_t^I + y_t^E] = 0 \tag{9}$$

Migration may now be permanent, temporary, or the migrant may be indifferent between migrating or not migrating, depending on whether, for all $t \in (0,1)$, $(y_t^I + y_t^E) > 0$, $(y_t^I + y_t^E) < 0$, or $(y_t^I + y_t^E) = 0$, respectively. An interior solution evolves when there exists a $t^0$, $t^0 \in [0,1]$, for which $(y_t^I + y_t^E) = 0$. In Appendix 2 it is shown that this may well be the case when human capital, accumulated in the host country, is only earnings effective in the home country. In this special case, temporary migration may evolve in a deterministic environment, although the migrant is indifferent between consumption in either country and although he bases his decision on purely monetary criteria.

## 2.2 Savings of Migrants and Natives

There are a variety of explanations why individuals accumulate savings. People may save because life time profiles of income and desired consumption do not coincide. Savings are thus a means to transfer consumption over time. Savings of this kind are said to be due to life cycle motives. A further reason to save are precautionary motives. Precautionary savings are induced by uncertainty about future income streams. Individuals save to have funds for future contingencies. Savings may also be due to bequest motives. Savings would here be a means to provide capital for children or other heirs.

The following analysis will concentrate on the first two motives. It will be shown that both, savings that are due to life cycle motives, and savings that are due to precautionary motives, may differ considerably between migrant workers and comparable natives.

### Life Cycle Motives

In simple intertemporal models, savings that are referred to as life cycle savings occur when the individual's rate of time preference differs from the interest rate. Individuals save or desave, depending on whether the rate of time preference is smaller or larger

than the interest rate. In the present model framework, the interest rate and the rate of time preference are both assumed to be equal to zero. Accordingly, there is no difference between both rates which could induce savings. Since the purpose is to compare savings of migrants and natives, this restriction translates into the assumption that savings induced by such a difference are equal between migrants and natives. What remains are life cycle savings that accrue because profiles of lifetime income differ from profiles of lifetime consumption. It will be shown that this may be major reason why migrants have a different savings behavior than native workers.

Consider a migrant worker who's decision problem is characterized by the above optimization problem. His earnings prospects abroad are higher than those at home. However, he prefers to consume at home rather than abroad. His savings in the host country that are due to life cycle motives consist then of two components: first, holding the flow of consumption constant over the life cycle, he will save because earnings are higher abroad than at home. Secondly, holding the income stream constant over the life cycle, he will save because desired consumption is higher at home than abroad.

Before formalizing these arguments, a native reference group has to be characterized. Define therefore a *comparable* native as one who maximizes lifetime utility over the same horizon $T$ and who has the same path of human capital accumulation as the migrant worker. Furthermore, since the native lives in his home country, let his lifetime utility function be equal to the subutility function of the migrant worker in the emigration country. Assume, for simplicity, that both migrant and native have a constant stock of human capital over the horizon $T$. Denote earnings per unit of time in the emigration- and the immigration country by $w^E$ and $w^I$, respectively, with $w^E < w^I$. Accordingly, migrant and native receive equal earnings in the immigration country. The total savings rate $s$ is given by:

$$s = \frac{w^I - c^I}{w^I}$$

How would this savings rate differ between native and migrant, when both were observed at the same point in time during the migrant's stay abroad? The lifetime budget constraint of the native worker corresponds to $t\,w^I + [1-t]\,w^I = c^I$. Given his utility function $V^N = t\,u^I(c^I) + [1-t]\,u^I(c^I)$, he will choose a constant $c^I$ over his life cycle that is equal to $w^I$. Consequently, his savings rate is equal to zero.[15]

[15]Remember that savings that are due to differences in interest rate and rate of time preference are

The migrant's budget constraint is, according to (3), given by $t\,w^I + [1-t]\,w^E = t\,c^I + [1-t]\,c^E$. Neglect any fixed costs of migration ($\eta = 0$). The migrant's savings rate $s^M$ consists then of two components, savings that are due to discontinuities in his life cycle income stream ($s_1^M$) and savings that are due to discontinuities in his stream of desired consumption ($s_2^M$):

$$s^M = s_1^M + s_2^M = \frac{w^I - w^E}{w^I}[1-t] + \frac{c^E - c^I}{w^I}[1-t] = \frac{w^I - c^I}{w^I} \tag{10}$$

The rate $s_1^M$ is positive whenever $w^I > w^E$: in this case, future earnings will decrease. Life cycle earnings of the migrant are lower than those of the comparable native, although they both have equal earnings in the immigration country. The prospect of lower future earnings would then induce the migrant to accumulate savings.[16] The share of $s_1^M$ in the total savings rate depends on the size of the wage differential and on the length of the desired migration period.

Additionally, migrants may save because they have a preference for consumption at home. The corresponding savings rate is given by $s_2^M$. Savings are accumulated to allow for an increase in the flow of consumption upon return. The share of $s_2^M$ in the total savings rate depends on the extent of migrant's preference for consumption at home and, again, on the length of the time abroad. The size of $s_2^M$ depends additionally on the price level abroad. Should the price level be higher in the immigration country than in the emigration country ($p > 1$), it follows from (8-b) that the migrant would further reduce consumption abroad, relative to consumption at home. Consequently, a higher price level in the immigration country would reinforce the size of $s_2^M$.

Consequently, when migration is intended to be temporary,[17] life cycle motives may induce migrant workers to have savings rates that are higher than those of comparable native workers. The total rate of savings of a migrant worker is the higher, the larger the differential between wages at home and abroad, the stronger the preference for consumption at home and the higher the relative price level abroad. The savings rate decreases with the length of migration.

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excluded by assumption.

[16]This is essentially the motive for savings that is analyzed by Galor and Stark (1990). For wages being lower in the home country, Galor and Stark illustrate in a two-period model that migrants savings in the first period are the higher, the higher their return probability in the second period.

[17]The analysis would also include the case where migration is desired permanent (because a preference for consumption abroad), but is restricted being temporary (because legal restrictions, like e.g. in Switzerland). In this case, $s_2^M$ would be negative.

**Precautionary Motives**

The second explanation for a different savings behavior between migrants and natives are precautionary motives. In what follows, the migrant's optimal savings- and consumption decision in the host country under small uncertainty about future income will first be compared with that under certainty. It is then shown that precautionary savings of migrant workers are likely to be higher than those of comparable native workers.

Let $t^0$ and $c^{I0}$ be the optimal length of stay and the optimal level of consumption in the host country, when $x$ and $z$ are known to be equal to their expected values $\tilde{x} = E(x)$ and $\tilde{z} = E(z)$. In other words, $t^0$ and $c^{I0}$ solve (8). To compare the optimally chosen level of consumption in the deterministic case, $c^{I0}$, with that chosen under small uncertainty, expand (7-a) around $x = \tilde{x}$ and $z = \tilde{z}$. Neglecting terms of order higher than 2, and assuming that $y^E$ and $y^I$ are linear in $x$ and $z$, respectively, this results in the following expression (derivation see Appendix 3):

$$E^0(u'^I(c^I) - u'^E(c^E)) \approx -\frac{1}{2}\frac{1}{[1-t]^2} u'''^E(c^E)\,[Var(y^E + y^I)] \qquad (11)$$

where $E^0(.) = E(.)$ when $z = \tilde{z}$ and $x = \tilde{x}$. It follows from the second order conditions that $\phi_{c^I c^I} < 0$ (see Appendix 1). Accordingly, $d\ E^0(u'^I(c^I) - u'^E(c^E))/dc^I < 0$. Therefore, the optimally chosen level of consumption in the host country under small uncertainty is smaller or larger than that chosen in the certainty case, depending on whether the term on the right hand side of (11) is negative or positive, respectively. Since $Var(y^E + y^I)$ will always be positive, the sign of the term on the right of (11) depends on the sign of $u'''^E(c^E)$, indicating the change in the attitude towards risk when $c^E$ changes. When $u'''^E(c^E) = 0$, the optimal level of consumption is not affected by uncertainty. This is, for instance, the case for a quadratic utility function.

However, for $u'''^E(c^E) > 0$, it follows from (11) that $c^{I0} > \hat{c}^I$, where $\hat{c}^I$ is the optimal level of consumption when small uncertainty about income at home and abroad is present. It is easy to show that $u'''^E(c^E)$ has to be positive when absolute risk aversion is decreasing and the utility function is additively separable (see Leland (1968))[18] If the migrant's utility structure exhibits decreasing absolute risk aversion, he would, under small uncertainty, accumulate precautionary savings and increase the level of

[18]For an extensive discussion of the properties of the third derivative of the utility function and its impact on savings behavior, see also Mirman (1971) and Sandmo (1971).

consumption in the home country even if he were indifferent between consumption at home and abroad. The interesting question that arises is whether precautionary savings of migrant workers differ from those of comparable natives.[19]

It is obvious from (11) that the impact of uncertainty on the savings decision depends on the size of $Var(y^E + y^I)$, the variance of lifetime income. $Var(y^E + y^I)$ may be rewritten as:

$$Var(y^E + y^I) = Var(y^E) + Var(y^I) + 2\,Cov(y^E + y^I) = [y_x^{I2}\sigma_x^2 + y_z^{E2}\sigma_z^2 + 2\rho y_x^I y_z^E \sigma_x \sigma_z] \tag{12}$$

Accordingly, the variance of the migrant's lifetime income consists of the variance of total incomes in the host- and in the source country, both depending positively on the time spent in either country, and on the covariance between both. The degree of risk exhibited by the respective labor market may be measured by $\sigma_i^2$, $i = z, x$. Assume first that the random variables $x$ and $z$ are uncorrelated.

The variance of lifetime income of a migrant worker, and, accordingly, his precautionary savings, may then be higher than that of a comparable native worker for two reasons: the variance of income to be accumulated in the host country is higher than that of the native worker, or/and the variance of income to be accumulated at home is higher than that of the native worker, both evaluated over the same period length $t$.

First consider $Var(y^I)$, the variance of total income to be accumulated abroad. Evaluated for the same $t$, $Var(y^I)$ is higher for migrant workers than for comparable natives if migrants perceive the host country labor market as more risky than native workers. It is likely that this is the usual case. For instance, in many immigration countries migrant workers do not have the same rights in the labor market or the same benefit entitlements than native workers. Furthermore, discrimination may prevent migrant workers from having the same opportunities to stay in the job, or to find a new job, especially during economic downturns. The variance of lifetime income for a migrant worker would then be higher than that of a native worker, given that the

[19]Since the analysis of precautionary savings requires at least a two-period framework, assume, as before, that the life of the comparable native is divided into two periods of unequal length, period 1 corresponding to $t$ and period 2 to $(1-t)$. Comparisons of savings of migrant workers with those of natives refer then to the first period.

variance of income in the home country over the remaining period $[1-t]$ is not lower than that of the respective native worker over that period.[20]

Secondly, higher precautionary savings of migrants may be induced by the desired, temporary nature of migration. If the migrant stays only temporarily in the host country, and, after return, enters the labor market of the home country, the variance of his lifetime income depends on the riskiness of the home country labor market. Emigration countries are often characterized by poorly developed benefit systems.[21] They usually exhibit fairly high rates of unemployment, low stability and are sometimes highly sensitive to economic shocks. Therefore, the variance of the migrant's income to be accumulated after return may be high, thus further increasing the variance of lifetime income, respective to that of a comparable native worker.

Furthermore, the correlation between the effects of some shocks on the labor market of emigration and immigration country may well be positive or negative. In this case, not only the variances of $y^E$ and $y^I$, but also the covariance between $y^E$ and $y^I$ determines the size of $Var(y^E + y^I)$. A positive correlation between total incomes to be accumulated at home and abroad would signify that the same type of event has either a positive or a negative effect on labor markets and earnings in both countries. A negative correlation would correspond to opposite effects on labor markets in the two countries.

Assume, for instance, that the emigration country is a net importer of some raw materials, e.g. crude oil, while the immigration country is a net exporter. A rise in oil prices would then have a positive effect on the economy of the immigration country and a negative effect on the economy of the emigration country. On the contrary, if both economies were net importers of crude oil, a rise or fall in oil prices would affect both economies similarly.

[20]The variance of total income to be accumulated in the host country should be particularly high for illegal migrants. They usually do not have the right to claim any benefit support in the host country. Furthermore, their illegal status prevents them from appealing to any labor market law that concerns minimal wages or job security.

[21]Although institutionally established benefit systems are often less developed in potential emigration countries, it would be wrong to conclude that migrants are always better off in immigration countries. Less economically developed emigration countries have very often a well-functioning, non-institutionalized benefit systems that is based on kinship and family. While the migrant worker may rely in his home country on family support in the case of unemployment or illness, he may end up with no benefits at all, if the host country benefit system discriminates against foreigners.

The correlation of the effect of such an event on labor markets and, accordingly, earnings is captured by the correlation coefficient $\rho$ in (12). When $\rho = 0$, total incomes in the two countries are uncorrelated. Should $\rho < 0$, some shock would have opposite effects on the two economies. This allows the migrant to hedge against risk. For a negative correlation, there exists an optimal level of consumption and an optimal length of time abroad so that all risk would be removed from the migrant's decision problem. Accordingly, the correlation between the effects of some random shocks on the labor markets, mirroring characteristics and interdependencies of the economies considered, may weaken or reinforce the size of precautionary savings.

Consequently, when the utility structure of migrants exhibits decreasing absolute risk aversion, migrants are likely to accumulate precautionary savings that are higher than those of comparable natives. The size of savings that are due to precautionary motives depends on the perceived riskiness of the host country labor market and the home country labor market, determining the variance of total earnings in either country, and on the length of migration. It further depends on the correlation of the effects of some shock on labor markets in both countries.

## 2.3 Uncertainty and Migration Decisions

Uncertainty does not only influence migrant's savings in the host country, as was shown above, but also his optimal length of stay abroad and, when analyzed around $t^0 = 0$, the migration decision itself. To investigate the effect of income uncertainty on the optimal choice of $t$, denote $t^0$ and $c^{I0}$ as those realizations of $t$ and $c^I$ which solve the migrant's decision problem when $x$ and $z$ are known to be equal to their expected values. Expanding (7-a) around $x = \tilde{x}$ and $z = \tilde{z}$, and assuming that $y^I$ and $y^E$ are linear in $x$ and $z$, respectively, results in the following expression (for the derivation see Appendix 3):

$$E^0[u^I(c^I) - u(c^E)] + E^0\left[u'^E(c^E)\left[\frac{dc^E}{dt}[1-t]\right]\right] \approx \Delta^1 + \Delta^2 = \Delta \tag{13}$$

$$\Delta^1 = \frac{1}{2}\frac{1}{[1-t]^2}\left[u'''^E(c^E)\frac{dc^E}{dt} + u''^E(c^E)\right]\ [Var(y^E + y^I)]$$

$$\Delta^2 = \frac{1}{2}\frac{1}{[1-t]}\,u''^E(c^E)\left[\frac{d}{dt}\,Var(y^E + y^I)\right]$$

where $E^0$ again indicates that the expectations are evaluated at $x = \tilde{x}$ and $z = \tilde{z}$. For $\phi_{tt} < 0$ (see Appendix 1), the term on the left decreases in $t$. As a result, the optimally chosen level of $t$ under small uncertainty, $\hat{t}$, is smaller or larger than that chosen in the deterministic case, $t^0$, depending on whether $\Delta$ is smaller or larger than zero:

$$\hat{t} \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} t^0 \quad \text{if} \quad \Delta \left\{ \begin{array}{c} > \\ = \\ < \end{array} \right\} 0$$

Uncertainty affects the optimal choice of $t$ directly and indirectly. Directly because the migrant is risk averse. Indirectly because a change in $t$ changes the variance of total lifetime earnings, and, by way of altering $c^E$, changes the attitude towards risk. The direct effect of risk aversion and the indirect effect via a change in the degree of risk aversion are captured by $\Delta^1$. The indirect effect via a change in the variance of total lifetime income is captured by $\Delta^2$.

Consider first $\Delta^1$: since $Var(y^I + y^E) > 0$, the sign of $\Delta^1$ depends on the sign of $u'''^E(c^E)$. It further depends on the magnitudes of $u'''^E(c^E)\,[dc^E/dt]$ and $u''^E(c^E)$. For a given variance of total lifetime income, $u''^E(c^E)$ captures the direct effect of uncertainty on the choice of $t$. The term $u'''^E(c^E)[dc^E/dt]$ represents the indirect effect by a change in the attitude towards risk, caused by a change in desired consumption at home, $c^E$, that results from a change in $t$.

Given the structure of the problem, decreasing absolute risk aversion would imply that $u'''^E(c^E) > 0$. Accordingly, for $dc^E/dt = [y_t^I + y_t^E - c^I + c^E] > 0$, an increase in $t$ would, by way of increasing the flow of consumption in the home country, increase the willingness to accept some given risk and influence the length of migration positively. However, since the direct effect is negative ($u''^E(c^E) < 0$), the sign of $\Delta^1$ is ambiguous.

The second indirect effect is induced by the impact of a change in $t$ on the variance of total lifetime income. This effect is captured by the term $\Delta^2$. Since $u''^E(c^E) < 0$, the sign of $\Delta^2$ depends on the sign on $dVar(y^E + y^I)/dt$. When, for some $t^0$, $dVar(y^E + y^I)/dt < 0$, an increase of the time being in the host country will reduce the variance of total lifetime income. This would be the case when, for instance, the labor market of the home country is very risky, relative to that of the host country.

Consequently, risk aversion would then induce the migrant to increase the length

Table 1: Changes in the Variance of Lifetime Income ($\frac{1}{2}\frac{d}{dt}Var(y^I + y^E)$)

| CORR | $(0 < t^0 < 1)$ | $t^0 = 0$ |
|---|---|---|
| $\rho = -1$ | $\underbrace{\underbrace{[y_x^H\,\sigma_x - y_z^E\,\sigma_z]}_{>0 \text{ or } <0}\ \underbrace{[y_{xt}^I\,\sigma_x - y_{zt}^E\,\sigma_z]}_{>0}}_{>0 \text{ or } <0}$ | $\underbrace{\sigma_z\, y_z^E [y_{zt}^E\,\sigma_z - y_{xt}^I\,\sigma_x]}_{<0}$ |
| $\rho = 0$ | $\underbrace{\underbrace{[y_x^I\, y_{xt}^I\,\sigma_x^2}_{>0} + \underbrace{y_z^E\, y_{zt}^E\,\sigma_z^2]}_{<0}}_{>0 \text{ or } <0}$ | $\underbrace{y_z^E\, y_{zt}^E\,\sigma_z^2}_{<0}$ |
| $\rho = 1$ | $\underbrace{\underbrace{[y_x^I\,\sigma_x + y_z^E\,\sigma_z]}_{>0} + \underbrace{[y_{xt}^I\,\sigma_x + y_{zt}^E\,\sigma_z]}_{>0 \text{ or } <0}}_{>0 \text{ or } <0}$ | $\underbrace{\sigma_z\, y_z^E [y_{xt}^I\,\sigma_x + y_{zt}^E\,\sigma_z]}_{>0 \text{ or } <0}$ |

of stay abroad. This can directly be seen from (13): For $d\,Var(y^E + y^I)/dt < 0$, and $u''^E(c^E) < 0$, $\Delta^2 > 0$. Accordingly, should $\Delta^1 > 0$, or $(\Delta^1 + \Delta^2) > 0$, it follows that $\hat{t} > t^0$.

The sign of $d\,Var(y^E + y^I)/dt$ depends on the degree of risk in the respective labor markets, as represented by $\sigma_x$ and $\sigma_z$, and on the correlation between the random variables $x$ and $z$. For $\rho = -1$, $\rho = 0$ and $\rho = 1$, the first column in table 1 presents $[1/2]\,d\,Var(y^E + y^I)/dt$ when the solution of the deterministic problem is an interior one $(0 < t^0 < 1)$. The second column of table 1 gives $d\,Var(y^E + y^I)/dt$ when the solution of the deterministic problem would be $t^0 = 0$ (i.e. the objective function reaches it's maximum for $t^0 = 0$). Without further specification of $y^I$, $y^E$ and the distribution of $x$ and $z$ as well as the migrant's utility function and the income functions in both countries, it is ambiguous whether $\Delta^2$ will tend to have an increasing or a decreasing effect on the time spent abroad, compared with what would have been chosen under certainty. In other words, depending on the migration situation and the preference structure of the migrant worker, uncertainty may have a positive or a negative effect on the time the migrant intends to stay abroad.

The effect of $\Delta^2$ is more definite when the migration decision itself is considered. Neglecting the effect of $\Delta^1$, column 2 of table 1 shows that uncertainty with respect to future income would induce the migrant to migrate, even if he would not do so under perfect foresight, when $x$ and $z$ are negatively correlated or not correlated. This is due to the purpose of the migrant to hedge against risk or to diversify risk, respectively.

However, when $x$ and $z$ are positively correlated, the effect of $\Delta^2$ on the migration decision is again ambiguous.

**An Example**

A simple numerical example may help to illustrate the above arguments. Assume the migrant's utility structure to be of the following simple form:

$$u(c^I) = G\, c^{I\,0.5}; \qquad u(c^E) = F\, c^{E\,0.5}$$

where $F$ and $G$ are indices which capture environmental arguments, like family, friends etc. The utility function has the property that $u''' > 0$. Let $F > G$, and normalize by setting $G = 1$.

Assume that total earnings in host- and home country, $y^I$ and $y^E$, are linear in $x$ and $z$, as well as in $t$ and $[1 - t]$:

$$y^I = w^I\, t\, x; \qquad y^E = w^E\, [1 - t]\, z$$

Again, $w^I$ and $w^E$ denote earnings per unit of time in immigration and emigration country.

Assume some numerical values. Suppose that $w^E = 1$, $w^I = 2$ and $F = 2$. Accordingly, wages in the host country are double as high as in the home country. Further, let the price level between host- and home country be equal ($p = 1$), and set the fixed costs of migration to zero ($\eta = 0$).

When the random variables $x$ and $z$ are known to be equal to their expected values, and expectations are equal to unity ($E(x) = E(z) = 1$), the optimal flows of consumption at home and abroad and the optimal length of migration are given by the following numbers:

$$c^I = \frac{1}{3}; \quad c^E = \frac{4}{3}; \quad t = \frac{1}{6}$$

Consequently, the migrant would intend to spent $1/6$ of his future life abroad. His consumption per unit of time abroad would only be $1/4$ of what he plans to consume in his home country. His total savings rate $s^M$, consisting of $s_1^M$ and $s_2^M$, is given by:

$$s^M = s_1^M + s_2^M = 0.416 + 0.416 = 0.83$$

In this simple example, the migrant would intend to save 83% of his wage income.

Consider now the case of uncertainty. Let the random variables $x$ and $z$ have means of unity, variances $\sigma_x^2$ and $\sigma_z^2$ and covariance $\sigma_x \sigma_z \rho$.

Three situations will be examined. In situation 1, the migrant perceives the labor market of the home country as riskier than that of the host country. In situation 2, the opposite is the case: the migrant considers the host country labor market as riskier than that of the home country.[22] In situation 3, the host country labor market is likewise riskier than that of the home country, but the difference in the degree of risk is smaller. The following values will be assumed:

- Situation 1: $\sigma_x = 0.5$; $\sigma_z = 0.8$
- Situation 2: $\sigma_x = 0.9$; $\sigma_z = 0.3$
- Situation 3: $\sigma_x = 0.8$; $\sigma_z = 0.5$

In all situations, the migrant will accumulate precautionary savings, since $u'''(.) > 0$. For the assumed utility structure, the effect of uncertainty on the desired length of migration depends on the riskiness of the two labor markets, as well as on the correlation between the effects of some event on them. Table 2 presents qualitative results for $d\,Var(y^I + y^E)/dt$, $\Delta^1$, $\Delta^2$, and $\Delta^1 + \Delta^2$.

In situation 1, a further stay abroad would increase the variance of lifetime income ($Var(y^I + y^E)$) for $\rho = 1$. It would decrease the variance of lifetime income for $\rho = 0$ and $\rho = -1$. In situation 2, an increase in $t$ increases the variance of lifetime income for all $\rho$'s. In situation 3, the variance rises likewise, except for $\rho = -1$. The direct effect of risk aversion and the effect of a change in the degree of risk aversion on the optimal length of migration, as represented by $\Delta^1$, is positive in all situations and for all $\rho$'s. It therefore affects the desired time abroad positively. However, $\Delta^2$, which captures the

[22]Note that the labor market of the host country may exhibit a different degree of risk for the migrant than for the native worker. The degree of risk depends on the extent to which the foreign labor market is discriminative against migrant workers, the migrant's legal rights to claim benefit support in the case of unemployment, illness etc.

Table 2: The Impact of Uncertainty on Migration Decisions

| CORR | $dVar(y^I + y^E)/dt$ | | | $\Delta^1$ | | | $\Delta^2$ | | | $\Delta^1 + \Delta^2$ | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| SITUATION | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) | (1) | (2) | (3) |
| $\rho = 1$ | (+) | (+) | (+) | (+) | (+) | (+) | (-) | (-) | (-) | (+) | (-) | (-) |
| $\rho = 0$ | (-) | (+) | (+) | (+) | (+) | (+) | (+) | (-) | (-) | (+) | (-) | (+) |
| $\rho = -1$ | (-) | (+) | (-) | (+) | (+) | (+) | (+) | (-) | (+) | (+) | (-) | (+) |

effect of a change in the total variance of lifetime income on the optimal $t$, is negative in situation 1 for $\rho = 1$. It is negative for all correlations in situation 2. In situation 3, it is again negative for $\rho = 1$ and $\rho = 0$, but positive for $\rho = -1$. Summing up $\Delta^1$ and $\Delta^2$, the total effect of uncertainty in situation 1 would be to increase the length of the migration period, compared to what would have been chosen under certainty. In situation 2, uncertainty has a decreasing effect on the desired length of stay abroad. Finally, in situation 3, the effect is negative for $\rho = 1$ and positive for $\rho = 0$ and $\rho = -1$.

This exercise should have demonstrated that income uncertainty affects the migrant's desired length of stay and, in the limit, the migration decision itself. However, the effect is not conclusive without specifying the migrant's optimization problem explicitly. Depending on the migrant's preference structure, the specification of the income functions and the distribution of and correlation between the random variables $x$ and $z$, uncertainty may increase or reduce the desired time in the host country, relative to that chosen under certainty.

## 2.4 *Type 2* Uncertainty

So far, only the impact of *type 1* uncertainty has been analyzed. Additionally to *type 1* uncertainty, *type 2* uncertainty may influence the migrant's decision problem.

With *type 2* uncertainty, the potential migrant is before migration uncertain about how the foreign labor market evaluates his abilities and his stock of human capital. However, once arrived in the foreign country, he will gather information about the requirements of the labor market and thereby reduce uncertainty.

Uncertainty that is due to imperfect information is likely to play a minor role

when there is an established and long-lasting migration relation between target- and source country. Returners may have thoroughly informed new potential migrants about the immigration country.[23] However, for the first wave of migrants, *type 2* uncertainty may play a major role in the decision process. Which kind of uncertainty finally dominates, depends on the migration situation under consideration. Although both types of uncertainty are likely to affect the migrant's optimization problem simultaneously, the effect of *type 2* uncertainty on the decision variables will be analyzed separately.

Since *type 2* uncertainty only affects earnings abroad, assume earnings at home as certain. Define $\xi$ as the random variable that reflects uncertainty which is due to imperfect knowledge about the foreign labor market. Let $g(\xi)$ be the known density function of $\xi$, with variance $\sigma_\xi$. Future income abroad is then given by $y^I(t,\xi)$. Given that the stock of knowledge about the foreign economy rises while the migrant stays abroad, an increase in $t$ should reduce uncertainty that is due to imperfect knowledge. It therefore seems to be reasonable to adopt the assumption of *decreasing risk*: $y^I_{t\xi} < 0$.

Consider first precautionary savings: the variance of total lifetime income, $Var(y^E + y^I)$, reduces to $y^{I\,2}_\xi \sigma^2_\xi$, which is always positive. Accordingly, uncertainty that is due to imperfect knowledge would likewise induce the migrant to accumulate precautionary savings.

To analyze the effect of *type 2* uncertainty on the length of migration, one has to evaluate $\Delta^1$ and $\Delta^2$. The sign of $\Delta^1$ is again ambiguous. The sign of $\Delta^2$ depends on $dVar(y^E + y^I)/dt$, which reduces to $dVar(y^I)/dt = y^I_\xi \sigma_\xi y^I_{\xi t}$. This term is always negative since $y^I_\xi$ decreases in $t$. Accordingly, and neglecting the effect of $\Delta^1$, the effect of $\Delta^2$ alone would then always be to increase the time to be spent in the host country. This is a direct result of *decreasing risk* when uncertainty is due to imperfect information.

# 3 Conclusion

The aim of the above analysis was twofold: First, to analyze the motives that may be responsible for the surprisingly high saving rates of migrant workers. Secondly, to investigate the impact of uncertainty with respect to future incomes on the migration

[23] An example would be migration of turkish workers to Germany during the early seventies, after the two countries have had an established migration history of nearly two decades.

decision and the length of time the migrant intends to stay abroad.

The analysis isolates two motives which may explain to some extent why temporary migrants often have savings that are considerably higher than those of comparable native workers: life cycle motives and precautionary motives. Savings that are due to life cycle motives are likely to be higher for migrants than for native workers. The difference between saving rates is the greater, the larger the wage differential between home- and host country, the stronger the migrant's preference for consumption at home and the higher the relative price level in the immigration country. It decreases with the length of migration.

The migrant may further accumulate precautionary savings. For uncertain future income flows in home- and host country, the magnitude of precautionary savings depends on the size of the variance of future income. It is shown that this variance is likely to be larger for migrants than for native workers. In particular, precautionary savings are likely to be higher for migrants when foreigners can not claim the same rights in the labor market of the immigration country than native workers, when the labor market of the host country discriminates against foreign workers, when the migrant has an illegal status, and when the labor market of the home country exhibits a high degree of risk and instability, leading to a high variance of income to be accumulated after return. These effects are reinforced by a positive correlation between the impact of some random shocks on the labor markets considered, and weakened by a negative correlation.

The effect of uncertain future income on the migration decision and the length of the migration period is inconclusive. It depends on the specification of the utility structure and the income structure of the migrant. It further depends on the perceived degree of risk exhibited by both labor markets and the correlation between the impact of random shocks on labor markets in both countries considered.

Uncertainty affects both the decision to migrate as well as the desired length of stay. The analysis shows that this effect is generally ambiguous, not only in size, but also in sign. Accordingly, conclusions for one migration situation, and for one type of migrant may be inappropriate when another migration situation and another type of migrant worker are considered.

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# 4 Appendix

### Appendix 1: The Sufficiency Conditions

Let $\psi(c^I, t, x, z) = t\,u^I(c^I) + [1-t]\,u^E(c^E)$ for any $x$, $z$ defined over the range $(\underline{x}, \bar{x})$ and $(\underline{z}, \bar{z})$, where $\underline{x}$, $\underline{z}$ and $\bar{x}$, $\bar{z}$ are the lower and upper limits of the distributions of $x$ and $z$, respectively. Then it follows for $\psi_{c^I\,c^I}$:

$$\psi_{c^I\,c^I} = t\,u''^I(c^I) + \frac{t^2}{[1-t]}\,p^2\,u''^E(c^E) \tag{14}$$

and for $\psi_{tt}$

$$\psi_{tt} = [1-t]\,u''^E(c^E)\left[\frac{dc^E}{dt}\right]^2 - u'^E(c^E)\,\frac{dc^E}{dt} + u'^E(c^E)\,[y^I_{tt} + y^E_{tt}] \tag{15}$$

$\psi_{c^I\,c^I}$ is definitely negative. $\psi_{tt}$ is smaller than zero for $y^I$ and $y^E$ being concave in $t$. However, when $y^I$ and $y^E$ are convex in $t$, as it would be the case when human capital accumulation is allowed for (see Appendix 2), then $\psi_{tt} < 0$ iff $|[1-t]u''^E(c^E)[dc^E/dt]^2 - u'^E(c^E)[dc^E/dt]| > |u'(c^E)[y^I_{tt}+y^E_{tt}]|$. That this is the case will be assumed throughout the analysis. Furthermore, $\psi_{t\,c^I} = -p\,t\,u''^E(c^E)[dc^E/dt]$. It follows that $\psi_{c^I\,c^I}\,\psi_{tt} > \psi^2_{t\,c^I}$. Since $\psi$ is concave in $c^I$, $t$ for all $x$, $z$, the same must be true for $\phi = E(V(c^E, c^I))$.

### Appendix 2: Changes in the Stock of Human Capital

The functions of total income abroad and at home, $y^I$ and $y^E$, may well be nonlinear in $t$. To see this, consider the deterministic case and denote by $\bar{y}^I(t)$ and $\bar{y}^E(t)$ total earnings accumulated at home and abroad, respectively. Let $v^I$ be the rental rate on one *unit* of human capital stock abroad and $v^E$ be the rental rate on one *unit* at home. Assume the accumulation of human capital as exogenous and as independent of whether the migrant stays abroad or at home. Denote the stock of human capital in $t$ by $h(t)$, with $h'(t) > 0, h''(t) < 0$. The strict concavity of the human capital stock is in line with human capital theory and compatible with empirical evidence [see Dustmann (1990, 1991)]. Denoting $t$ as the point of re-migration, total lifetime earnings are then given by $\bar{w}$:

$$\bar{w}(t) = \bar{y}^I(t) + \bar{y}^E(t) = \int_0^t v^I\,h(\tau)\,d\tau + \int_t^1 v^E\,h(\tau)\,d\tau \tag{16}$$

Specify, for instance, $h(t)$ as $[h(t) = \gamma + t^{0.5}]$. Inserting in (16) and solving yields:

$$\bar{w}(t) = [v^I - v^E]\left[\gamma\,t + \frac{1}{1.5}\,t^{1.5}\right] + v^E\left[\gamma + \frac{1}{1.5}\right] \tag{17}$$

Each additional unit of time spent abroad increases lifetime earnings by $\bar{w}_t = \bar{y}_t^I + \bar{y}_t^E$:

$$\bar{w}_t = [v^I - v^E][\gamma + t^{0.5}] \tag{18}$$

Equation (18) is positive for $v^I > v^E$. The profile of $\bar{w}$ is then a strictly convex function of $t$:

$$\bar{w}_{tt} = 0.5\,[v^I - v^E]\,t^{-0.5} \;>\; 0 \tag{19}$$

An interesting case to consider is now the following: the migrant accumulates human capital while being abroad. In the host country, he does not receive a higher pay for this additional human capital. It increases, however, his potential earnings in the home country. In other words, the additionally acquired human capital is only earnings effective back home.

Such a situation could occur if the migrant has no occupational choice in the host country, or he may by purpose accumulate human capital that is only of use later in the home country. In such a situation, migration may be temporary, although the migrant is indifferent between consumption at home and abroad and although initially wages are higher abroad.

To see this, assume the extreme case: let the migrant accumulate human capital abroad, but only get paid for this additional stock of human capital back home. For the above specification of the human capital function, lifetime income is then:

$$\bar{w}(t) = \int_0^t \gamma\, v^I\, d\tau \quad + \int_t^1 v^E\,[\gamma + \tau^{0.5}]\, d\tau \tag{20}$$

and

$$\bar{w}_t = \bar{y}_t^I + \bar{y}_t^E = \gamma\,[v^I - v^E] - v^E\, t^{0.5} \tag{21}$$

For this specific example, migration would be temporary if there exists a $t \in [0,1]$ that solves $\bar{w}_t = 0$, i.e. when $\{\gamma\,[v^I - v^E]/v^E\}^2 = t^*$ and $0 < t^* < 1$.

## Appendix 3: Derivation of equations 11 and 13.

A second order expansion of (8-a) around $x = E(x) = \tilde{x}$ and $z = E(z) = \tilde{z}$, and neglecting higher order terms, yields:

$$E[u'^H(c^H) - (u'^E(c^E))] \approx u'^I(c^I) - u'^E(c^{E0}) - \int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty} \left\{ \frac{\delta}{\delta\, x}\, u'^E(c^E)\,[x - \tilde{x}] \right.$$

$$+\frac{\delta}{\delta z}u'^{E}(c^{E})[z-\tilde{z}]+\frac{1}{2}\frac{\delta^2}{\delta x^2}u'^{E}(c^{E})[x-\tilde{x}]^2+\frac{1}{2}\frac{\delta^2}{\delta z^2}u'^{E}(c^{E})[z-\tilde{z}]^2$$

$$+\frac{\delta}{\delta x\,\delta z}u'^{E}(c^{E})[x-\tilde{x}][z-\tilde{z}]\Big\}\,f(x,z)\,dx\,dz \qquad (22)$$

where all derivatives are evaluated at $x=\tilde{x}$ and $z=\tilde{z}$. When assuming that $y^I$ and $y^E$ are linear in $x$ and $z$, respectively, (22) simplifies to:

$$E^0\left[u'^{I}(c^I)-u'^{E}(c^E)\right]\approx u'^{I}(c^{I0})-u'^{E}(c^{E0})-\frac{1}{2}\frac{1}{[1-t]^2}u'''(c)\,[y_x^{I2}\,\sigma_x^2+y_z^{E\,2}\,\sigma_z^2+2\,\rho\,y_x^I\,y_z^E\,\sigma_x\sigma_z] \qquad (23)$$

Expanding $Var(y^I+y^E)$ around the mean values of $x$ and $z$ yields (for linear risk):

$$Var(y^I+y^E)=Var(y^I)+Var(y^E)+2\,Cov(y^I,y^E)\approx[y_x^I\,\sigma_x^2+y_z^{E\,2}\,\sigma_z^2+2\,\rho\,y_x^I\,y_z^E\,\sigma_x\sigma_z] \qquad (24)$$

Substituting into (23):

$$E^0(u'^{I}(c^I)-u'^{E}(c^E))\approx u'^{I}(c^{I0})-u'^{E}(c^{E\,0})-\frac{1}{2}\frac{1}{[1-t]^2}u'''^{E}(c^E)[Var(y^E+y^I)] \qquad (25)$$

Since the first order condition of the deterministic problem requires that $u'^{I}(c^{I0})-u'^{E}(c^{E0})=0$, (11) follows directly from (25).

The derivation of (12) follows the same lines:

$$E^0[u^I(c^I)-u^E(c^E)]+E^0\left[u'^{E}(c^E)\frac{dc^E}{dt}[1-t]\right]\approx u^I(c^{I0})-u^E(c^{I0})+$$

$$u'^{E}(c^{E0})\left[\frac{dc^E}{dt}\right]^0[1-t]+\int_{-\infty}^{+\infty}\int_{-\infty}^{+\infty}\left\{\frac{\delta}{\delta x}\left[u'^{E}(c^E)\frac{dc^E}{dt}[1-t]-u^E(c^E)\right][x-\tilde{x}]\right.$$

$$+\frac{\delta}{\delta z}\left[u'^{E}(c^E)\frac{dc^E}{dt}[1-t]-u^E(c^E)\right][z-\tilde{z}]+\frac{1}{2}\frac{\delta^2}{\delta x^2}\left[u'^{E}(c^E)\frac{dc^E}{dt}[1-t]\right.$$

$$\left.-u^E(c^)\right][x-\tilde{x}]^2+\frac{1}{2}\frac{\delta^2}{\delta z^2}\left[u'^{E}(c^E)\frac{dc^E}{dt}[1-t]-u^E(c^E)\right][z-\tilde{z}]^2$$

$$\left.+\frac{\delta}{\delta x\,\delta z}\left[u'^{E}(c^E)\frac{dc^E}{dt}[1-t]-u^E(c^E)\right][x-\tilde{x}][z-\tilde{z}]\right\}f(x,z)\,dx\,dz \qquad (26)$$

where $c^E=\frac{1}{1-t}[y^I+y^E-t\,c^I-\eta]$ and $\frac{dc^E}{dt}=\frac{1}{1-t}[y_t^I+y_t^E-c^I+c^E]$

After some tedious calculations, (26) simplifies to:

$$E^0[u^I(c^I) - u^E(c^E)] + E^0\left[u'^E(c^E)\frac{dc^E}{dt}[1-t]\right] \approx u^I(c^{I0}) - u^E(c^{E0}) +$$

$$u'^E(c^{E0})\left[\frac{dc^E}{dt}\right]^0[1-t] + \frac{1}{2}\frac{1}{[1-t]^2}\left[u'''^E(c^E)\frac{dc^E}{dt} + u''^E(c^E)\right][y_x^{I2}\sigma_x^2 + y_z^{E2}\sigma_z^2 + 2y_x^I y_z \sigma_{xz}]$$

$$+\frac{1}{[1-t]}u''(c)[y_x^I y_{xt}^I \sigma_x^2 + y_z^E y_{zt}^E \sigma_z^2 + [y_{xt}^I y_z^E + y_{zt}^E y_x^I]\sigma_{xz}] \quad (27)$$

It follows from (24):

$$\frac{d}{dt}Var(y^E + y^I) = 2[y_x^I y_{xt}^I \sigma_x^2 + y_z^E y_{zt}^E \sigma_z^2 + [y_{xt}^I y_z^E + y_{zt}^E y_x^I]\sigma_{xz}] \quad (28)$$

Again, it follows from the first order conditions of the deterministic problem that $u^I(c^{I0}) + u^E(c^{E0}) + u'^E(c^{E0})\left[\frac{dc^E}{dt}\right]^0[1-t] = 0$. Consequently, substituting (28) into (27) yields (13).

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